

## **Life in the Dark: Corals, sponges, and gravitation in late seventeenth natural philosophy**

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**Abstract** This chapter examines how the borderline cases pointed out by English naturalists and philosophers in the second half of the seventeenth-century call into doubt the common notion of life as a vegetative power. In the first part of this chapter, I focus on Nehemiah Grew’s notions of life and living beings by comparing his plant anatomy, in which he examines the cases of sponges and corals, with his physico-theology. In the second part, I confront Grew’s views on life to those of John Ray and Ralph Cudworth. My aim is threefold. First, I want to show that there was then no agreement on what a “vital phenomenon” is. Second, I want to emphasize the fact that what we would classify today as physical phenomena, such as gravitation, were then regarded as living phenomena. Third, and accordingly, I would like to challenge the view that the English naturalists and philosophers who then developed a physico-theology simply used empirical vital phenomena in order to refute Descartes’ metaphysics. In my view, there were no such things as “empirical vital phenomena.” Indeed, the very identification and description of the phenomena considered as “vital” was a matter of interpretation, and those different authors did not share the same set of assumptions regarding what kinds of beings are alive. At the very least, they do not share the set of assumptions that define what we regard as “vital.”

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*And for the essence of vital principles, we are yet more in the dark.  
As having little more knowledge hereof, than of their operations (Grew 1701, 54)*

### **Introduction**

In the *Essay concerning human understanding*, Locke claimed that we have no “clear distinct settled idea” of what “life” is:

Life is a term, none more familiar. Any one almost would take it for an affront to be asked what he meant by it. And yet if it comes in question, whether a plant, that lies ready formed in the seed, have life: Whether the embryo in an egg before incubation, or a man in a swoon without sense or motion, be alive or no; it is easy to perceive that a clear distinct settled idea does not always accompany the use of so known a word as that of life is (Locke, 1979, III, X, §22)

Locke was not the only one interested in the natural phenomena that questioned our common understanding of the differences between living and non-living things. At the end of the seventeenth century, medical, anatomical, and natural observations were full of borderline cases which called into question the boundaries between animate and inanimate, between plants and animals: the description of corals, sensitive plants, or unconscious patients challenged the usual taxonomy of beings. For example, in 1670, the physician Theodor Kerckring, wondered if a patient, a young woman who could no longer feed herself, was still alive: he spoke then about a “*diuturna mors*”, a durable death, rather than life (1670, 156). In the same decade, Johannes Swammerdam questioned the similarity between the contractility of muscular fibers in animal bodies and the spontaneous motions of the plant called “impatiens of Dodona” (1758, 592). Those cases challenged the very notion of life, which seems at first sight very simple, but turns to be, after careful examination, dreadfully difficult to delimit and define.

This chapter examines Nehemiah Grew’s natural history, which offers an interesting perspective on the taxonomy of living beings in the late seventeenth century. Grew first developed in the 1670s a plant anatomy underlain by the mechanistic idea that there is a strong continuity between physical and living phenomena; he then wrote a catalog of “natural rarities,” such as sponges and corals, that agrees with the morphological and chemical approach he endorsed in his plant anatomy. None of these works contains considerations on life or on the boundaries of the animate world. It was only twenty years later, in his apologetic book entitled *Cosmologia sacra*, that he introduced the thesis that there is in nature a vital world that exceeds the powers of matter. Cases of “vegetation”, whether in plants or animals, thus demonstrate for Grew the existence of a “vegetative life,” distinguished from a “sensible” one. And yet, these notions raise more issues than they resolve. How do they fit the empirical criteria that Grew uses in his natural history? How do the borderline cases with which he deals in his catalog of rarities fall into these different species of life? By addressing these questions, my purposes are twofold: first, I want to question the very notion of “vital empirical phenomena” (Garrett 2003, 74); second, I want to emphasize the fact that the notion of life had then no taxonomic value. In the last part of this chapter, I confront my analysis of Grew’s natural philosophy to Cudworth’s and Ray’s notion of “plastic life,” which raises the same kind of problems.<sup>1</sup>

### **Nehemiah Grew’s natural history**

Nehemiah Grew (1641-1712) was a Calvinist physician, who graduated from Cambridge in 1661, and obtained a doctorate in medicine from Leiden in 1671. From 1661 until 1671, Grew likely practiced medicine in Coventry, before moving to London to become a fellow of the Royal Society thanks to his works on the anatomy of plants. In 1673, he published an *Idea of a Phytologic History*, and in 1682, an *Anatomy of Plants*, which collected previous publications communicated to the Royal Society. Between 1677 and 1680, he was the secretary of the Society, for which he wrote a catalogue of the rarities preserved at Gresham College (1681; see Hunter 1981). After this, he resumed his medical practice in London and Coventry. His last published book, the *Cosmologia Sacra, or Discourse of the Universe as it is the Creature and Kingdom of God* (1701), was not a work of natural history as such, but rather a text of physico-

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<sup>1</sup> On the notion of plastic life in Cambridge Neo-Platonists and on Cudworth, see Hutton in this volume

theology which aimed at “demonstrating the Truth and Excellency of the Bible,” against the Anti-Scripturists,” like “Spinoza and some others.” The book is divided into five parts dealing respectively with the corporeal world and “nature’s geometry;” the existence of a vital world; Providence and God’s government; the “Hebrew Code;” and, lastly, the New Testament. In the first and second books, Grew thus placed his knowledge of natural history at the service of an apologetic undertaking. And yet, the principles that he defended in the *Cosmologia Sacra*, and particularly the three kinds of incorporeal “principles of life,” did not fit the natural history he had proposed twenty years earlier.

Indeed, in the *Anatomy of Plants*, which was regarded as a pioneering work, Grew explained plant organism in terms of the mechanical interactions between particles (Arber 1921; Arber 1942, 16; Hunter 1982, 189). According to Grew, “vegetation,” that is, the growth and reproduction of plants, is due to operations such as filtration and fermentation, which mainly depend on the size and shape of the organs involved in the process –particularly the shape of the fibers that compose them—, and on their chemical nature. The proportion of the various chemical principles, i.e. nitrous, acid, alkaline and marine salts, is what explains the various faculties and powers of plants. As for these chemical principles themselves, they come from the microscopic “geometry” of nature, that is, from the respective position, shape, and motion of the small invisible particles that compose the various parts of plants. But “Grew’s adherence to the mechanical theory of matter did not bring about his rejection of chemical principles” (Clericuzio 2000, 162; see also Roos, 87-8): chemical principles simply correspond with the relevant level of explanation when the powers of plants, for example the purgative character of rhubarb, are at stake. To illustrate this anti-reductionist position, Grew used the example of the clock: to explain the functioning of a clock, it is not enough to describe its various preexistent parts; one should also describe the exact combination of parts that specifies a clock:

So the *Principles* of the Purgative Parts of a *Root*, as of *Rhubarb*, although we should suppose them to be existent in the surrounding *Earth*, yet we cannot say, That *that Earth*, or the *Principles* therein contained, are Purgative; but only that they are such, as by being combined together, in such a peculiar way, may become *so*. So the several parts of a *Clock*, although they are and must be all prae-existent to it [...]; yet is it the *setting together* of such *Parts*, and in such a way only, that makes them a *Clock* (1682, “An Idea of a Philosophical History of Plant” §55, 21).

It is only when Grew addresses the question of the formation of roots that he speculates on the invisible components that ultimately account for the actions of chemical principles:

[The] first Intention of *Nature* is, That some of those *Parts* be disposed to *Rest* [...] And the *Particles* of *Marine Salt*, being *Cubick*; and so, with respect to their *Figure*, of greater *Bulk* than those of any other *Salt*; they will hereby be most and first of all disposed to *Rest*; and so become, as it were, the Foundation of the following *Superstructure*.

The Second Intention of Nature is, That the *Particles* be brought to *Rest*, in a certain *Position*, agreeable to the *Figure* of the *Parts* which are to be formed. And therefore in the next place, all those *Parts* of a *Plant* which are truly *Lignous*, by the *Marine Salt*, with the assistance of the *Alkaline*, but especially of the *Nitrous*, are made to shoot out in Length, or into an innumerable company of small *Cylindrick Fibres* [...]

The next Intention is, That these *Fibres*, at the same time in which they are formed, may likewise receive such a *Posture* as will best answer the indented *shape* of the *Leaf*. (Grew 1682, IV:6 §10-12, 159)

In all cases, the interactions between particles that underlie the formation of the “anatomy of plants” first described by Grew are mechanical. A few paragraphs after the one just cited, Grew took up the Galilean notion that nature is written in a mathematical language: “Thus doth *Nature* everywhere *γεωμετρειν*. For what She appears in Her *Works*, She must needs be also in their *Causes*” (Grew 1682, IV:6 §19, 160). Beyond his work in plant anatomy, Grew adopted a conception of the universe as a “Great Engine,” which he deems entirely compatible with “Religion, and the Sacred Scriptures:”

So *God* may be truly the *Cause of This Effect*, although a Thousand other *Causes* should be supposed to intervene: For all *Nature* is as one *Great Engine*, made by, and held in His Hand. And as it is the *Watch-makers Art*, that the *Hand* moves regularly, from hour to hour, although he put no his Finger still to it: So is it the *Demonstration of Divine Wisdome*, that the *Parts of Nature* are so harmoniously contrived and set together; as to conspire to all kind of *Natural Motions and Effects*, without the *Extraordinary and Immediate Influence of the Author* of it (Grew 1682 II §5, 80).

The harmonious combination of the different parts of nature thus guarantees the regularity and productivity of the physical processes at stake –in this instance, the formation and growth of roots. Grew does not admit any vital principle that would be fundamentally irreducible to the physical interactions of plant particles.

Actually, Grew’s experimental studies do not include any reflection on the general criteria for life, nor on the notion of a specifically vegetative life: in the *Anatomy of Plants*, there is nearly no mention of “life”, “vitality,” or soul of any kind, except in the expression “vital sap,” or “vital part,” for example, which mean the essential parts of a plant, or the kinds of parts that a certain species of plant has to have (1682, I:2 §23, 15; 1682 I:6 §4, 41). In addition, his plant anatomy is partly grounded in analogies with animals. For example, the description of the ascent and distribution of the “sap,” or “vital sap,” is supported by analogies with blood and nervous spirit in animals:

So that as in an *Animal Body* there is no instauration or growth of *Parts* made by the *Bloud* only, but the *Nervous Spirit* is also thereunto assistant; so is it here: the *Sap* prepared in the *Cortical Body*, is as the *Bloud*, and that part thereof prepared by the *Lignous*, is as the *Nervous Spirit* (Grew 1682, I:2 §23, 15)

In other words, Grew does not regard plants as specific living beings endowed with a vegetative soul or a principle of vegetative life: since they are natural “engines” among others, there is no reason to fundamentally distinguish them from minerals or animals.

In the *Musaeum Regalis Societatis, or a Catalogue and a Description of the Natural and Artificial Rarities Belonging to the Royal Society, and Preserved at Gresham College* (1681), Grew described several natural objects that questioned the limits of plant life: sponges, corals, kermes berries, and cochineal.<sup>2</sup> Regarding sponges, Grew first related the common view according to which a thing is considered as an animal if it is endowed with sense-perception. Grew did not express his disagreement with this common view, but rather questioned the criteria according to which a thing is regarded as endowed with sense. According to Grew, the

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<sup>2</sup> Grew describes also different kinds of shells and sea-porcupine, but their animal nature is apparently obvious for him and for his contemporaries.

contractile movement produced by the sponge when it is touched cannot be used as an indication of its animal nature:

It is the opinion of some, that *Sponges* have sense, because said to shrink, if they are pluck'd; and are therefore reckon'd amongst *Zoophyta*. But of that property I doubt very much. For a *Sponge* being a springy Body, and so extensible, and yielding a little to one that plucks at it; so soon as he lets his hold go, it will, from its elasticity, shrink up again. Which motion of restitution, some probably, have mistaken for the effect of a Cap-sense (Grew 1681, 252)

Elasticity, a property that belongs to every kind of body, suffices to explain the reactive motions of the sponge. Those movements are purely mechanical, and do not presuppose that the sponge has the kind of sense-perception which we observe in animals. The presence of reactive motions as such is not a proof of animalness.<sup>3</sup> Besides, the structure of the sponge suggests that it is a plant, and not a “zoophyte,” or a plant-animal:

No *Sponge* hath any Lignous Fibers, but is wholly compressed of those which make the Pith and all the pithy parts of a Plant. Yet vastly thicker, and their Texture much more rare or open, so as to be visible to a good eye, especially assisted with an ordinary Glass. So that a *Sponge*, instead of being a *Zoophyton*, is but the one half of a Plant (Grew 1681, 252).

Similarly, Grew mentions the “sensitive plant” without calling into question its inclusion in the plant kingdom. This plant “takes its Name (as is commonly known) from its Imitation of sense or Animal motion. For so soon as you touch the Leaves, they presently fall, till they lie upon the ground. After a while, they rise again; but being touched, fall as before” (1681, 234; on the sensitive plant, see for example Hooke 1665, 124; Giglioni 2018). However, as it is the case for sponges, the motility of sensitive plants is not a proof that they are animals and endowed with sense-perception. According to Grew, the unconscious and automatic motion of intestines and muscles “is imitated in a fainter degree, in those Plants, which are commonly, tho' unaptly, called sensitive” (*Cosmologia sacra*, 1701, 35). The criteria of color and structure, rather than motility, are equally decisive in the case of the “sea-blobber,” that is, of what we call today bladder-wrack, a sea-plant that could well be an animal, owing to its small brownish bladders:

'Tis a Cluster of Small roundish Bladders, almonst in the shape of little *Oystershells*; of a light brown colour, all over veined with Fibers, like the uter Cover of a *Plumpstone*. Which makes it the more doubtful, whether it be an Animal Body, or a Vegetable. Which soever, it is supposed the *Matrix* of a *Sea-Insect* (Grew 1681, 250).

Generally speaking, the three natural kingdoms do not seem to play a decisive role in Grew's classification and descriptions. With regard to corals, Grew simply explains: “These having

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<sup>3</sup> On this last criterion, see for example Digby: “For speaking rigorously, I cannot allow Plants to have Life. They are not *Se Moventia*. They have not a principle of motion within them” (1660, 70). Regarding sensitive plant, Webster argues: “the greatest obstacle to the recognition of plant sensitivity was the generally accepted distinction between plants and animals, which had been accepted since the writings of Aristotle and Theophrastus – that plants were characterized by an insensitive Vegetative soul, while animals had a sensitive soul. Animals made active responses to external stimuli, while plants were passive, having only the faculties of nutrition and reproduction. This principle had such authority that the seventeenth century proponents of plant sensitivity won only limited approval.” (1966, 6).



also a resemblance unto plants, and a near analogy unto those stones, last described in the precedent chapter [i.e. petrified plants], they may therefore not unaptly be here subjoyn'd” (275). Nothing here implies that Grew really considers corals as stones. Actually, Grew does *not* think that corals are minerals, since he relates Boyle’s hypotheses about their reproduction.<sup>4</sup> But in the *Musaeum*, he did not at all address the question of whether corals are animals or plants. First, the corals of the museum of Gresham College are by definition dead corals, or skeletons of corals belonging to the mineral kingdom. Second, an apparent resemblance between two kinds of natural objects, as well as a common opinion about their nature, suffices to justify the order Grew follows in this catalog. For example, he regards “kermes berries” as animals, because of their fetid smell when they are burnt, but describes them in the chapter given over to mosses and mushrooms “in compliance with the Vulgar Opinion”:

[As] the Pulp or Powder, so called, is a Cluster of small Animals: so the Husk itself is Animal Body, as it were grafted on the Stock or Leaf, whereon it grows; and so converteth all the nourishment it deriveth thence (as *Bread* eaten is turned to *Flesh*), into its own Animal Nature. And that the said Husk is really an Animal Body, appears by that *fetid* scent it gives, like that of *Horns*, *Hair*, and the like, upon its being burnt. A property, which I find belonging to no *Plant* whatsoever, except to some *Sea-Plants* [...]. So that, though in compliance with the *Vulgar Opinion*, I have placed it here, yet ought it to be treated of amongst *Animals* (1681, 240).

Grew uses again this chemical criterion of animality for the cochineal:

To me, thus much seems evident, That’ tis neither a *Vegetable Excrecence*, as some surmise; nor an *Insect*, as others: yet an *Animal Body*, as the *Kermes Berry*, by some *Insect* affixed to a *Plant*; and thence nourished for a time, but gather’d before it be fill’d with *Mites* or *Maggots*. For being held, as the *Kermes Berry*, in the flame of a *Candle*; it usually huffs and swells, but always stinks, like *Hair* or *Horn* when they are burnt (Grew 1681, 241).

And yet, as Grew indicates about kermes berries, sea-plants also have a fetid scent when they are burnt, even though they belong to the plant kingdom: “All Sponges stink, more or less, upon burning, as the *Horny Sea-Shrubs*. So that it is a property belonging to most of the *Vegetable Productions in the Sea*” (1681, 251-252). We have thus the following situation: in most cases, a “fetid scent” is a criterion of animalness, but in some cases, it can also suggest that the object under examination is a sea-plant. Grew’s chemical criterion dividing plants from animals is not very systematic.

To put it briefly, in his natural history, Grew does not seem to attach a lot of importance to the question of whether the natural object he describes is a mineral, a plant, or an animal. In the rare cases where he raises this question, his criteria, which are merely morphological and chemical, seem neither systematic nor robust.

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<sup>4</sup> “On the Nature and Generation of *Coral*, it is affirmed by the Honourable Mr. *Boyle*, That whilst it grows it is often found soft and succulent, and propagates its *Species*” (Grew, 1681, 278).

## Nehemiah Grew’s physico-theology

At the time when he wrote the *Anatomy of Plants*, Grew did not distinguish between minerals, plants, and animals, through the criteria of motion or sense-perception. In addition, he never mentioned the neo-Aristotelian tripartition between reason, sense-perception, and vegetative soul. His natural history dealt only with *bodies*, whether mineral, vegetal, or animal. Grew’s apologetic book, the *Cosmologia Sacra*, which was published more than twenty years later and aimed at refuting materialism, is partly in accordance with his earlier views regarding the boundaries and the functioning of the plant kingdom. In addition, in the first book of the *Cosmologia Sacra*, Grew uses the very idea of a “geometry of nature” that he first presented in the *Anatomy of Plants*. His new notion of the “organism” of a body then summarizes Grew’s anatomical research on this natural geometry (Cheung 2006, 319; Andrault 2014, 37):

How admirable also is *the natural Structure or Organism of Bodies*? The whole Body of a Plant, whether Herb, Shrup, or Tree, is composed of two Species of Fibers, so artificially managed; that all the Parts, from the Root to the Seed, are distinguished one from another, only by different Position, Proportion, and other Relations and Properties, of those two sorts of Fibers: As I have made to appear, in the *Anatomy of Plants* (Grew 1701, 18).

However, in the first chapter of the second book of the *Cosmologia Sacra*, entitled “Of Life,” Grew introduces the usual tripartition of the principles of life which was completely absent from his earlier works. According to this text, there is a “vital” and incorporeal world that completes the corporeal world and partly accounts for it:

Life and Motion, being, as is said, the two instruments of Commerce, between the Vital and the Corporeal worlds. Whence also the union of Soul and Body, and of all things Vital and Corporeal, is nothing else, but the Congruity between the Life and Motion, which they either have, or are Capable of. Now the several Species of Life, seem to be reducible unto these Threes; viz. Vegetable Life, Sense, and Thought. The lowest Species of Life, whereof we can have any conception, is such a sort of Life, as is without Sense (Grew 1701, 34).

Grew endorses a dualistic conception of nature in which there are two kinds of beings: beings that are corporeal, mechanical, or more generally body-like, on the one hand, and those that are “incorporeal,” “vital,” or more generally soul-like, on the other hand. Grew articulates this dualistic conception of nature with a tripartition of the incorporeal principles, which are divided into three different species of life, according to an Aristotelian framework. “Vegetable life,” “sense” and “thought” are thus the main components of the vital kingdom, in contrast to the corporeal world. Generally speaking, there is nothing original in that. We can find similar views in Ralph Cudworth’s *True Intellectual System of the Universe* (1678), which also aimed at the refutation of the so-called atheistic tendency of Descartes’ mechanical philosophy, in the same manner as Henry More’s *Antidote against Atheism* (Duchesneau, 169-181; Hutton 2015, 139, 142-3, and 161). Like Cudworth, Grew adopts two different conceptions of life (Andrault 2014, 37). On the one hand, according to a generic conception of life, what is vital is incorporeal, and vice versa. For example, Grew argues in the very beginning of the second book that “there is a Vital Substance in Nature, distinct from a Body. [...] God, who as he is the Cause of all other Beings, is the most Substantial Being: is Himself a Substance Vital and Incorporeal” (1701, 31). In this sense, life is an “incorporeal” power that may account for a large range of

natural capacities, from growth and reproduction to sensorial perception to reason: life explains what is not explicable physically, i.e. in terms of the mechanical motions and shapes of invisible corpuscles. Grew’s notion of life is clearly opposed to Descartes’ view, according to which life is a mechanical process, guaranteed by the continual movements of blood and nervous fluid (1701, 32-3). On the other hand, according to its specific conception, life is sometimes identified with vegetative life, that is to say, with the lowest common denominator of all the things that are regarded as living beings.<sup>5</sup> According to a common view, this lowest species of life, which is the only one which animates plants, is characterized negatively, by the lack of sense-perception:

[It] is the same Vegetable Life, whereby these Operations are performed in Animals, as well as in Plants. And which are still going on, while we are asleep, and all our Senses locked up. [...] There are Sundry motions, both in Plants and Animals, depending upon this Vegetable Life. The motion of restitution, in the Bladders of the Barque and Pith, for the expressing of their Liquors, may hereby be promoted. [...] A motion, whereof we have no perception, as depending on the vegetable life in an animal. As also doth the Peristaltick Motion of the Arteries. [...] As then, Hairs and Feathers, are Plants growing upon an Animal; so these are vegetable motions, in an Animal. And therefore, though Vital, yet have nothing to do with Sense (Grew 1701, 35).

Classically enough, vegetative life is also partly responsible for the generation of bodies, because “for the performance of this Work, a Vital or Directive Principle, seemeth of necessity to be assistant to the Corporeal.” Most notably, the vegetative principle of life produces the specific “mixtures” that determine the actions of the corporeal principles. In both cases, according to the general sense of life, which refers to incorporeal principles, and the specific sense of life, which refers specifically to vegetative power, “life” is sharply distinguished from the “corporeal,” i.e. the mechanical world.

What is original in Grew’s conception of life is rather the fact that he refuses to identify it with a source of motion, or a dynamic power. Indeed, according to the Cartesian conception of matter, the quantity of motion remains constant in the universe.<sup>6</sup> Consequently, the different species of life cannot produce new motion; they only transfer it in a certain manner:

Yet neither by this Life, nor the Subject of it, do I mean, a Principle of Motion. The Universal Stock of Motion, as that of Matter, being neither encreased, nor diminished, but only transfer’d. But I mean, a certain Power to determine the manner of its being transfer’d; or of returning an Impression upon Bodies, suitable unto that which it receives (Grew 1701, 35).

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<sup>5</sup> On the connection between plants and vegetative soul, see Baldassari 2018, 513-4.

<sup>6</sup> Grew’s mechanical conception of matter is somehow difficult to combine with his rehabilitation of vital principles. On this point, see Garrett: “Bayle ends with a sentiment that Grew would have found congenial: like most Cartesians Grew denies that matter can have the power of self-movement. But Grew has not realized that the postulation of a vital principle allows the atheist to assert the coherence of self-moving or directive matter after all [...] But as Bayle points out, the postulation of a vital principle, naturally compatible with matter, and capable of directing matter, leaves the atheist with the conceptual resources to explain teleological phenomena without God. The atheist threat of active self-moving matter is not lessened by the appeal to Grew’s vital principles and this irony was not lost on the theist Pierre Bayle” (2003, 81).



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Vegetative life transfers motion immediately, without retaining it, in contrast to animal life. It was rather new not to define vegetative life by its passivity, or lack of motion, but rather by the manner in which it transfers motions:

The difference between Vegetable and Sensible Life, seemeth to be this; that in the former, the Impression arising from the Motion, is entirely reflected, and lost in an Instant. In the latter, it is Immersed and retain'd.

Does this difference between “vegetable life” and “sensible life” fit the empirical criteria Grew used in his natural history? Does this conceptual difference agree with the descriptions of borderline cases which Grew presents in his *Cosmologia Sacra*? In other words, is there a discrepancy between the conceptual tripartition of the species of life and the empirical identification of a thing as a plant or an animal? At first sight, there is no contradiction between them. For instance, Grew regards the *urtica-marina*, i.e. the sea-nettle, as well as the *aurelias*, i.e. insect nymphs, as endowed with sense-perception; he does not reduce them to plant life:

The next Species of Life, above the Vegetable, is that of Sense. Wherewith some of those Productions, which we call Plant-Animals, as the *Urtica Marina*, and the like, are endowed, as their highest Species of Life. In which rank, we may also place the *Aurelias* of all Creeping Insects (Grew 1701, 37).

Even if Grew does not explain this view, and does not try to connect it with his definitions of vegetative life, one can consider that the sea-nettle and the nymphs are endowed with sense-perception because they do not reflect the motion they receive immediately, in contrast to the sensitive-plant which immediately contracts its leaves when it is touched. However, it remains difficult to explain Grew’s notion of vegetative life by means of all the examples he includes in the *Cosmologia Sacra*. Indeed, Grew regards the motions of which we have no perception, and particularly the organic motions that are performed in our body when we are asleep, as “depending upon the Vegetable Life” (1701, 35):

whereby the Vegetable Life, is made so far independent on the Sensible: that notwithstanding the perpetual Motion and Clutter in all the rooms of the House, viz. our bodies; yet we take no notice at all of it, nor are in the least, hinder'd or diverted, from any thing we have to do, as Animals, or as Men (Grew 1701, 36).

But in what sense are the internal motions of an animal or a man asleep immediately “reflected” –and not “retained and immersed”–, to take up Grew’s own definition of “vegetable life”? According to Grew, the development of feathers and hairs depend also on vegetative life. But is it really possible to identify the slow development of hairs with a vegetative movement understood as the immediate “reflection” of a motion received? What is the difference between the inner motions of the insects in the chrysalid and the organic motions of a man asleep? Why is the first regarded as depending on a “sensible life,” while the second is said to be produced by the vegetative life? In the case of an animal asleep, the specificity of the vegetative life seems to consist only in the lack of awareness during the performance of the automatic movements. But if this is the case, how is it possible to claim that the nymph and the sea-nettle have more than a vegetative life, that is to say, that they are endowed with sense-perception and awareness? Is it even possible to ascribe sense-perception to a natural being by means of merely observational criteria? In addition, Grew denied, in the *Anatomy of Plants*, that the sensitive

plant is an animal by arguing that its movement could simply be explained mechanically, by the mere elasticity of matter. Why, then, in the *Cosmologia Sacra*, where he still considers the “sensitive plant” as a plant, does he regard more generally the automatic “motion of restitution, in the Bladders of the Barque and Pith” of plants as the effects of an incorporeal vegetative principle (1701, 35)?

The difficulty of Grew’s notion of “vegetable life” is not only due to the discrepancy between, on the one hand, the empirical approach to plant phenomena he adopted in his *Anatomy of Plants* and *Musaeum Regalis Societatis*, and, on the other hand, the apologetic use of those same phenomena he developed in the *Cosmologia Sacra*. The problem is more general, and concerns the difficulty in making conceptual distinctions between different species of life that agree with anatomical investigations. Grew combines a dualism, which aims at refuting materialism, with a neo-Aristotelian tripartition of the species of life that was common, and very intuitive, but does not easily fit into his mechanical approach to physical phenomena. Such a mechanical conception implies, on the contrary, a certain continuity within nature, particularly between simpler and more complex phenomena, which allows the naturalist both to use analogies between species and to give microscopic causes to macroscopic phenomena.

### **Life is everywhere... And nowhere?**

In his article “Vitalism and Teleology in the Natural Philosophy of Nehemiah Grew,” Brian Garrett claims that “[according] to the vitalist Grew, matter, active or otherwise, is insufficient to explain the empirical vital phenomena, and thus an incorporeal principle is required” (2003, 74). He adds that Grew’s “sensitivity to empirical phenomena reveals, as it did for many of his fellow Englishmen, the poverty of Cartesian explanations of living phenomena” (81). It is true that Grew considers Descartes’ natural philosophy as insufficient to explain vital phenomena. And it is not impossible that Grew’s empirical research eventually convinced him of this insufficiency –even if nothing in Grew’s natural history departs from mechanical philosophy. Nevertheless, the very notion of “*empirical vital phenomena*,” as well as the idea of the “poverty of Cartesian explanations of *living phenomena*,” may be misleading. They could suggest that a simple statement of fact suffices to claim the existence of living phenomena and to experimentally delimit the range of phenomena that are “vital,” in contrast to non-vital phenomena. And yet, this is not the case for three major reasons. First, acknowledging the existence of a vital world is a doctrinal option which is grounded in the sharp criticism of a merely physical approach to nature, both from an epistemological and a religious point of view. Second, according to Grew, life and vitality are not in themselves phenomena, but rather the causal principles of natural phenomena. Third, and more importantly, the limits of the phenomena that are only explicable by referring to vital principles are particularly uncertain. On the one hand, what Grew regards as endowed with life does not correspond to what we would regard today as a “vital phenomenon.” On the other hand, the boundaries of the non-vital world are not clearly drawn; it is not even sure that there are natural phenomena that are not partly caused by vital principles: it is not impossible that all the natural things require in one way or another the action of a vital principle –that is to say, that all phenomena are “vital” in some sense.

Indeed, Grew regards gravitation, “magnetic inclination,” and even colors, as the effects of a vital principle:

By virtue of this Power [Life], I suppose it is, That all Bodies have their Sphere of Activity, whereby they operate one upon another, more or less. That there are Dark Rays, as well as Light ones [...]. This aforesaid Power, from whence ariseth the Speer [*sic*] of Activity, is more conspicuous, in all the sorts of Magnetick Inclination, and in the Gravitation of all Bodies. But it is that also, wherewith every Corporeal Principle may probably be Endow'd: Or to speak properly, may be animated. (Grew 1701, 35).

In this paragraph, Grew contemplates the possibility that every corporeal principle is endowed with a principle of life. A few lines below, his statement is more affirmative:

On the Directive Power of the former [vital principle], and the Regularity of the latter [corporeal principle], whereby it is capable of Direction; depends the Generation of all Bodies. The said Power, being one and the same vegetable Life, infused into all the Parts of Corporeal Nature; but more remarquably into Plants and Animals (Grew 1701, 35).

First, the principle of life does not limit its action to the things that Aristotle regards as endowed with life (*De anima* 412a, 2011, 48). Second, it is not a principle of individuation. Indeed, the principle of vegetative life is neither proper to an *individual* thing, since it is “*infused* into all the parts of corporeal nature”, nor proper to a *living* thing, in contrast to a non-living thing, since it is a principle with which every corporeal principle is said to be endowed. For this very reason, it is not easy to understand the exact link between the “vital” (i.e. incorporeal) and the mechanical (i.e. corporeal). Generally speaking, they seem to be conceived of as two principles of explanation, if not two causal powers; but occasionally, they are rather presented as two “worlds” or two different kinds of things. In the first case, they can be mixed and can cooperate to produce one single phenomenon; in the second case, if the corporeal and the incorporeal refer to two kinds of things, it is more difficult to conceive of how “every Corporeal Principle” is maybe “endowed” with life (35).

In any case, we must acknowledge that there is no place in Grew’s physico-theology for an inanimate world with which we can compare the vital world. Indeed, if at first sight the “vital world” refers to the set of plants, animals, and human beings, it actually appears after scrutiny that vegetative life animates also bodies that are usually considered as inanimate. It is as though there was no part of the world where the effects of “life” were not mixed with the effects of the corporeal principles. In this sense, the notions of life and vitality do not have any particular “taxonomic” value (Foucault 1966, 173): they cannot help to classify phenomena or objects as either animate or inanimate.

One could object that Grew’s physico-theology lacks coherence, or that Grew is not representative of the thought of the other English philosophers that introduced into their natural philosophy some incorporeal principles of life so as to refute Descartes’ mechanism. But we can find similar statements in the theological works of the botanist John Ray, as well as in Ralph Cudworth’s *True Intellectual System of the Universe*, which inspired Ray’s physico-theology. To be sure, Grew, Ray, and Cudworth did not defend the same metaphysics. For example, Cudworth did not admit the Cartesian principle according to which the quantity of matter and the quantity of motion remain constant in the world. Accordingly, the principles of life that he admitted, and most notably “the plastic nature” and the “the plastic life of nature,” are dynamic powers that give new motions to a dead matter (Andrault 2014, 36).<sup>7</sup> However, despite their

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<sup>7</sup> For this reason, I do not think that Grew simply took up Henry More’s and Ralph Cudworth’s “vitalistic theories” (see Hutton 2015, 150).

differences and the different notions that they use to mean life and vital principles, they share with Grew the following set of assumptions. First, they endorse a clear dualism between physical entities and soul-like, or vital entities, which serves an apologetic undertaking. Second, they rehabilitate Aristotle’s tripartition of souls, which is presented as a common and intuitive opinion: they accept a vegetative life, responsible for generation, growth, and unconscious movements in living beings, and they deem that this vegetative life is distinct from an animal life, endowed with sense-perception and consciousness, or *synesthesia* (Cudworth 1678, I:3, §37, 159). Third, the rehabilitation of Aristotle’s tripartition is combined with semantic innovations and metaphysical indecisions that do not allow us to strictly identify Ray’s and Cudworth’s vegetative powers with a principle of individuation that operates in living beings only. Indeed, in both cases, it is not clear if “life” and vital principles are a kind of soul, a specific power of the soul, or a principle of another kind. It is not clear either if there is a soul for each individual, or rather a common soul or spirit for the whole nature. Lastly, exactly like More’s “spirit of nature,” those plastic or vegetative lives eventually “extend [their] operative domain to furnish explanations for all natural phenomena,” and not specifically for vital phenomena (Gabbey 1990, 28).

I will now turn to these two authors before concluding.

### **A brief comparison with John Ray and Ralph Cudworth**

John Ray (1627-1705), an English naturalist who studied at Cambridge, was also a fellow of the Royal Society from 1667 on.<sup>8</sup> His works include a huge *Historia Generalis Plantarum* (1686-1704), which proposed a system of classification, as well as a book entitled *The Wisdom of God* (1691; 1714<sup>6</sup>), which uses Ray’s plant and animal anatomy in order to demonstrate the necessity of an omniscient Creator. According to him “the formation and the organization of the Bodies of animals” cannot be explained by matter only, and require a “mental and final cause” (1714, 44). Those vegetative functions of formation, growth, and reproduction of plants and animals are said to depend on some “vital principles.” But for Ray, the actions of these principles go far beyond the vegetal and animal kingdoms:

So are there many *Phaenomena* in Nature, which being partly above the force of these *mechanick Powers*, and partly contrary to the same, can therefore never be salv’d by them, nor without *final Causes* and some *vital Principles*; As for example, that of Gravity or the Tendency of Bodies downward, the motion of the *Diaphragm* in Respiration, the *Systole* and *Diastole* of the Heart, which is nothing but a Muscular Constriction and Relaxation, and therefore not *mechanical*, but *vital*. We might also add, among many others, the Intersection of the Plains of the Equator and Ecliptick or the Earth’s diurnal motion upon an axis not parallel to that of the Ecliptick, nor perpendicular to the Plain thereof (Ray 1714, 43)

The range of “phenomena in Nature” that require the action of vital principles thus includes the gravity of bodies and the earth’s orbital motion. We have the same situation as in Grew’s

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<sup>8</sup> Incidentally, exactly like Nehemiah Grew’s father, John Ray lost his living in refusing to comply with the Uniformity act of 1662 (even though Ray continued to belong to the Church of England as a layman, and was not a Presbyterian like Obadiah and Nehemiah Grew). Their nonconformist religious opinions, which they shared with Ralph Cudworth, also educated in Cambridge, led them to develop their own theological views in the form of a physico-theology, closely related to their scientific knowledge of nature.

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*Cosmologia Sacra*: the reasons for admitting vital principles are not restricted to what we would call today “vital phenomena.” They include everything that appears to go beyond the explicative power of mechanism. Exactly like Grew whom he sometimes cites (1714, 59), Ray does not even make a distinction between gravity and animal movements. In addition, the motions of the heart are said “vital,” but Ray does not explain why it is the case.

This Pulse of the Heart Dr. Cudworth would have to be no Mechanical, but a Vital Motion, which to me seems probable, because it is not under the command of the will [...]. What directs and moderates the Motions of the Spirits [i.e. the animal spirits that are in the blood]? They being but stupid and senseless matter, cannot of themselves continue any regular and constant motion, without the guidance and regulation of some intelligent Being [...]

I should rather attribute them to a *Plastick Nature* or Vital Principle, as the Vegetation of Plants must also be (Ray 1714, 46-47).

One thing is certain: matter is conceived as purely mechanical; conversely, what is irreducible to the mechanical motions of a “stupid matter” is perceived as dependent upon vital principles. Those are thus immaterial. Because of these semantic equivalences, the vital principles could be produced by a vegetative soul distinct from an animal soul. But Ray prefers taking up Cudworth’s notion of a single immaterial plastic nature that would be responsible for the formation of all living beings. Indeed, Aristotle’s vegetative soul is supposed to account for the formation and growth of plants. But how, then, are we to explain the growth of cuttings? Is this vegetative soul divisible? The “vegetative soul, if that were the Architect, would be divisible, and consequently no spiritual or intelligent Being” (1714, 52). A “single Agent” must thus “preside over the whole Oeconomy of the Plant” (*id.*):

I therefore incline to Dr. Cudworth’s Opinion, that God uses for these Effects the subordinate Ministry of some inferior *Plastick Nature*; as in his Works of Providence he doth of Angels (Ray 1714, 52).

Ray thus endorses Cudworth’s thesis, according to which it is not God himself that causes the formation and growth of living beings, but an incorporeal “plastic nature” – i.e. a formative nature— that it is an intermediary between God and nature.<sup>9</sup>

The Cambridge Platonist Ralph Cudworth (1617-1688) published in 1678 *The True Intellectual System of the Universe: the First Part, wherein all the Reason and Philosophy of Atheism is Confuted and its Impossibility Demonstrated*, in which he propounded the theory that “a plastic nature,” or “the plastic life of nature,” causes the phenomena which he considers to go beyond the explicative power of mechanism.

The Occasion of which Miscarriage [of Descartes] hath been already intimated, namely from the acknowledging only *Two Heads* of Being, *Extended* and *Cogitative*, and making *the Essence of Cogitation* to consist in *Express Consciousness*; from whence it follows,

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<sup>9</sup> Ray targets Boyle’s *Free Inquiry into the Notion of Nature* here: “we [Ray and Boyle] are in the main agreed, differing chiefly about the Agent that executes those Laws, which he holds to be God himself immediately, we a *Plastick Nature*” (1714, 51). One of Ray’s arguments is the existence of monsters: if God were immediately responsible for the formations of bodies, the existence of monsters would remain inexplicable. Similarly, the “flow and gradual process that is in the generation of things” would be a “vain and idle pomp or trifling formality, if the Agent were omnipotent.”



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that there could be no Plastick Nature, and therefore either all things must be done by *Fortuitous Mechanism*, or else God himself be brought Immediately upon the stage, for the solving of all *Phaenomena*. Which Latter Absurdity, our Philosopher being over careful to avoid, cast himself upon the Former, the banishing of all *Final* and *Mental* Causality quite out of the World (Cudworth 1678, 1:3, §38, 175).

Life as such, that is vegetative life, lacks sense-perception and consciousness, as the well-known case of the sensitive plant shows:

clear and express consciousness is not essential to life. There is some appearance of life and vital sympathy in certain vegetables and plants, which however called sensitive plants and plant-animals, cannot well be supposed to have animal sense and fancy (Cudworth 1678, 1:3 §37, 160)

However, while lacking sense-perception, the plastic nature or the vegetative life is still something incorporeal:

But though the Plastick Nature be the Lowest of all Lives, nevertheless, since it is a *Life*, it must needs be *Incorporeal*; all Life being such (Cudworth 1678, 1:3 §37, 163)

According to Cudworth, as long as these vital principles are conceived of as incorporeal and as the “servants” or “drudging executioners” of God –and not as the immanent powers of the nature itself—, they are compatible with Christianity. But Cudworth is not firm on the metaphysical nature, or substratum, of these vital principles:

though it be not reasonable to think, that every Plant, Herb, and Pile of Grass, hath a Particular Plastic Life, or Vegetative Soul of its own [...]; yet there may possibly be, for ought we know, one Plastick Nature or Life belonging to the whole Terrestrial globe, by which all Plants and Vegetables, continuous with it, may be differently formed, according to their different Seeds, as also Minerals and other Bodies framed, and whatsoever else is above the Power of Fortuitous Mechanism effected (Cudworth 1678, 1:3, §37, 171).

Cudworth adds in the following page:

[Life lower than the Animal] is either a Lower Faculty of some Conscious Soul, or else an Inferior kind of *Life* or *Soul* by itself; but essentially depending upon a Higher Intellect (Cudworth 1678, 1:3, §37, 172).

But what is the exact link between the plastic life of the “terrestrial globe” which he presented first, and this vegetative faculty or soul of which he now speaks? Are there different kinds of plastic natures –that is to say, either the plastic natures which are souls of their own, or the single plastic nature which is “infused” into the whole earth to account for the growth of every pile of grass?

Regarding the metaphysical substrata of those vital principles, Ray has no definite claims either. Indeed, if he first endorsed Cudworth’s notion of a general plastic life of nature endowed with vegetative powers, in contradistinction to a vegetative soul, in other passages he seems simply to take up Aristotle’s vegetative soul:

Bodies are either Animate or Inanimate [...]. Animate bodies are either such as are endued with a vegetative soul, as plants; or a sensitive soul, as the bodies of animals, birds, beasts, fishes, and insects; or a rational soul, as the body of man (Cudworth 1714, 59; see also 100)

Ray takes up the common tripartition of animate beings (plants, animals, and human beings), which are respectively endowed with their corresponding soul, without endeavoring to articulate this tripartition with his notion of a plastic life. In addition, strikingly enough, Ray appeals neither to Cudworth’s plastic life of nature, nor to Aristotle’s vegetative soul when borderline cases of vegetation are at stake. Indeed, in his *Historia Plantarum*, he addresses the debated question of whether corals and other “lithophytes” are stones or plants. According to him, they are plants. However, the reason he puts forward has nothing to do with the definitional features of the vegetative soul. It is only the physical structure of the branches that suggests that corals grow by a process of intussusception, i.e. by the penetration of the nutritive fluid into the inner parts, in contrast to the process of the apposition of new particles by which stones are shaped (Ray 1704, Supplementum 2).

## Conclusion

As we carefully read the apologetic books written by Cudworth’s, Ray’s, and Grew’s –all bestsellers in the early eighteenth century–, we realize the vagueness of the notions of life and vitality. Those authors did not clearly delimit the exact operations produced by vegetative life, the exact metaphysical substratum of vital operations, and the exact range of bodies that have a vegetative soul. First, they refused to be dogmatic in this matter: they rather intended to articulate Christian philosophical tradition with common or “popular” views on living things, on their taxonomy, and their principles of action. Second, their “principles of life” were first and foremost a polemical tool against Descartes’ mechanism. Accordingly, they insisted on what Descartes’ mechanical notion of life failed to explain –not on what their own notions of an immaterial life should explain. They considered that a certain number of motions such as gravitation were “above” mechanism, and, for this very reason, were obviously “vital” and “incorporeal.” But they did not explain in what sense the growth of plants and the gravitation of bodies depend on the same vegetative power, or on the same kind of incorporeal principles of life. Are the so-called inanimate bodies, the sponges, and the corals endowed with the same vegetative life? And for the same reasons? Regarding gravitation, it is the notion of a directed force that leads Cudworth, Grew, and Ray to attribute to it vegetative life. Regarding sponges and corals, which, of course, do not manifest the same obvious force as gravitation, Grew and Ray rather appeal to their observable structure and chemical constitution as sufficient criteria for classifying them among plant kingdom. Moreover, when Grew addresses the case of the sensitive-plant or of the sponge, he prefers not to retain the criterion of spontaneous movement as a proof of animalness. Third, and most importantly, all three, in keeping with the practice of the period, do not assign to the notion of life a taxonomic role. On the one hand, they do not use the neo-Aristotelian tripartition of souls and powers to classify the objects under examination. As soon as they address borderline cases between minerals and plants, or between plants and animals, they rather use distinguishing criteria that are less systematic and more adapted to their own empirical approach. On the other hand, they show no concern for the

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boundaries between animate and inanimate in their empirical works.<sup>10</sup> They do not have the same interest for the limits of the living world as the physiologists of the nineteenth century and the biologists of the early twentieth century. Grew and Ray do not endeavor to defend the specificity of their subject matter; their works naturally include considerations on minerals and corporeal principles. Actually, there was in the seventeenth century no clear-cut line of distinction between mathematics, physics, natural history, and anatomy. For these reasons, we should not project onto these works our own conception of the boundaries of biology or of the distinction between the living and the non-living.

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## References

- Andrault, Raphaële. 2014. *La vie selon la raison. Physiologie et métaphysique chez Spinoza et Leibniz*. Paris: Champion.
- Andrault, Raphaële. 2014. “What is Life? A comparative Study of Ralph Cudworth and Nehemiah Grew.” In *The Life Sciences in Early Modern Philosophy*. Edited by Ohad Nachtomy et Justin Smith: 29-46. Oxford: Oxford University Press.
- Arber, Agnes. 1941. “The Tercentenary of Nehemiah Grew (1641-1712),” *Nature*, 147/3734: 630-2.
- Arber, Agnes. 1942. “Nehemiah Grew (1641-1712) and Marcello Malpighi (1628- 1694): An Essay in Comparison,” *Isis*, 34: 7-16.
- Aristotle. 2011. *De Anima. Of the Soul*. Translated by Mark Shiffman. Newburyport: R. Pullins Co.
- Baldassarri, Fabrizio. 2018. “Descartes’ Bio-Medical Study of Plants: Vegetative Activities, Soul, and Power.” *Early Science and Medicine*, 23/5-6: 509-529.
- Cheung, Tobias. 2006. “From the organism of a body to the body of an organism: occurrence and meaning of the word ‘organism’ from the seventeenth to the nineteenth centuries,” *British Journal of the History of Science*, 39/3: 319-339.
- Clericuzio, Antonio. 2000. *Elements, Principles, and Corpuscles. A Study of Atomism and Chemistry in the Seventeenth-Century*. Dordrecht: Kluwer Academic Publishers.
- Digby, Kenelm. 1660. *A Discourse Concerning the Vegetation of Plants*. London: Printed by J.C. for John Dakins.
- Duchesneau, François. 1998. *Les modèles du vivant de Descartes à Leibniz*. Paris: Vrin.
- Foucault, Michel. 1966. *Les mots et les choses. Une archéologie du savoir*. Paris: Gallimard.
- Gabbey, Alan. 1990. “Henry More and the Limits of Mechanism.” In S. Hutton (ed.), *Henry More (1614-1687). Tercentenary Studies*. Edited by S. Hutton: 19-35. Dordrecht: Kluwer.

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<sup>10</sup> See also Foucault 1966, 174: « Le naturaliste, c’est l’homme du visible structuré et de la dénomination caractéristique. Non de la vie. »

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- Garret, Brian. 2003. "Vitalism and teleology in the natural philosophy of Nehemiah Grew", *The British Journal for the History of Science*, 36/1: n°1, mar. 2003, 63-81.
- Giglioni, Guido. 2018. "Touch Me Not: Sense and Sensibility in Early Modern Botany." *Early Science and Medicine*, 23/5-6: 420-443.
- Grew, Nehemiah. 1682. *The Anatomy of Plants with an Idea of a Philosophical History of Plants, and Several other Lectures, read before the Royal Society*. London: Rawlins.
- Hutton, Sarah. 2015. *British Philosophy in the Seventeenth Century*. Oxford: Oxford University Press.
- Henry, John. 1986. "Occult qualities and the experimental philosophy: active principles in pre-Newtonian matter theory," *History of Science*, 24/365: 335-81.
- Hunter, Michael. 1981. "Early Problems in Professionalizing Scientific Research: Nehemiah Grew (1641-1712) and the Royal Society, with an Unpublished Letter to Henry Oldenburg," *Notes and Records of the Royal Society*, 36 (1981-2): 189-209.
- Kerckring, Theodor. 1670. *Spicilegium Anatomicum*. Amsterdam.
- Ray, John. 1686. *Historiae plantarum tomus primus*. London:
- Ray, John. 1704. *Historiae plantarum tomus tertius*. London
- Ray, John. 1714 [1691]. *Wisdom of God Manifested in the Works of the Creation. The Sixth Edition Corrected*. London: William Innys.
- Roos, Anna Marie. 2007. *The Salt of the Earth: Natural Philosophy, Medicine, and Chymistry in England, 1650-1750*. Leiden: Brill.
- Swammerdam, Johannes. 1758. *Collections académiques. Tome V de la Partie étrangère et le second volume de l'Histoire naturelle séparée. Contenant les observations de Jean Swammerdam sur les insectes*. Dijon: Desventes.
- Webster, Charles. 1966. "The recognition of plant sensitivity by English botanists in the seventeenth century," *Isis*, 57/1: 5-23.